National Park Service - Southwest Alaska Network
Inventory & Monitoring Program

SUMMARY

Freshwater Monitoring - Scoping Workshop
Southwest Alaska Network
Cooper Landing, Alaska
November 4-6, 2002

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Background

The Southwest Alaska Network (SWAN) held a freshwater monitoring workshop at the Kenai Princess Wilderness Lodge, Cooper Landing, November 4-6, 2002. The purpose of the workshop was to bring together National Park Service staff and invited experts to discuss ideas and options for building a statistically sound, ecologically-based, management-relevant, and affordable freshwater ecosystem monitoring program for SWAN park units. Participants included National Park Service resource managers and scientists, and invited experts in the areas of limnology, fisheries science, and chemical and physical hydrology (participants list and agenda attached). One month before the workshop, participants were furnished with a workshop notebook that contained background information on the network parks, draft conceptual models, maps, and objectives of the workshop.

This summary is a record of workshop discussions that we reconstructed from flip chart notes, personal notes, and written comments that participants entered in their notebooks. Any omissions or misinterpretations of statements made by participants is unintentional. In large measure, the summary is meaningful only in the context of information contained in the workshop notebook. We urge readers to refer back to those notebooks when reviewing this summary.

Workshop Objectives

1. Review/refine conceptual ecosystem models and monitoring questions
2. Identify drivers of change and why it is important to understand them
3. Identify candidate attributes to monitor that provide reliable signals about ecosystem condition

Invited Experts

Jim Larson, US Fish and Wildlife Service, Project Leader, King Salmon Fishery Resources Office, King Salmon, AK; **John Magnuson**, North Temperate Lakes LTER and Center for Limnology-University of Wisconsin, Madison, WI; **Joe Margraf**, Leader, Alaska Cooperative Fish and Wildlife Research Unit-University of Alaska, Fairbanks, AK; **Robert (Bob) Stallard**, USGS-Water National Research Program, Boulder, CO. The workshop was facilitated by **Phil North**, US Environmental Protection Agency, Kenai River Center, Kenai, AK.

Day 1 – Overview

Workshop participants arrived during the afternoon and became acquainted during a group social hour and dinner. After dinner, SWAN staff presented a slide program that showcased the variety of freshwater systems in each of the network park units. Question-and-answer and informal discussions occurred during and after the presentation.

Day 2 – Introductory Remarks

Introductory remarks made by Sara Wesser, Nancy Deschu, and Alan Bennett provided a brief overview of the National and Regional Inventory and Monitoring (I&M) Program, nationally identified core parameters for water quality monitoring, and the timeline for planning the SWAN program. Facilitator Phil North introduced the agenda and the procedures that would be followed during workshop discussions.

Prior to discussions, invited experts were given 10-15 minutes to introduce themselves and share their early thoughts on long-term monitoring, both in general and specific to what the SWAN is proposing to undertake.

Jim Larson- Jim has been at King Salmon for 13 years, a commendable accomplishment itself. He and his staff do a lot of fishery monitoring, primarily salmon escapement, focusing on the large lakes on the Alaska Peninsula. They have been working on sockeye but are beginning to transition over to other resident fish. Several National Wildlife Refuges butt against the parks so they have shared resources and there are potential partnership opportunities. Each refuge has a fish management and monitoring plan. However, the refuge plans are in need of updating and they need to address “landscape scale” thinking. His office would do the planning work for these refuges.

Jim recommended that we use the institutional infrastructure in hand and build on others efforts, to complement and add to our understanding. Look for partnership opportunities, both internally and externally. Coordinate freshwater with the terrestrial component of the I & M program. Becharof Refuge adjoins Katmai and they have a fish management and monitoring plan. Look at larger programs, such as the National Snow and Ice Data Center, which may already be collecting useful data.

John Magnuson- John reflected on the process that he was involved in 20 years ago setting up the North Temperate Lakes Long-term Ecological Research (LTER) site, with 8 individuals sitting around a table making decisions. The decisions seemed mundane then, but they revealed their underlying interest in the ecosystem. They purposively chose not to work on the most studied lakes. They chose to look at some lakes in northern Wisconsin that were “undisturbed.” They favored heterogeneity in their selections with the lake as the entity.

However, they learned in time that the lake should not be the entity. The entity should be a flow system, from the top to the bottom, linked by the gradient. They ended up picking an array of lakes from high to low in the landscape. They had a diversity from the context of flow. At some point later, Jim Brooks (head of the LTER network) looked at general design characteristics of LTER sites and found that many had independently adopted this same approach - going for the heterogeneity in the environment by looking at things across a gradient.

They ended up with some primary sites. These were the long-term sites where the core measurements were made. Then they had secondary sites, which were used opportunistically for experiments, when money was available. These came and went. You look at mechanisms of change with your other money.

John stressed the importance of location and connectivity and shifting from looking at single ecosystems to looking at connected sets of ecosystems. The focus should be on flow systems, such as lakes, from the top to the bottom, linked by the elevational gradient. Then think about other gradients, such as precipitation, volcanism, glacial versus non-glacial. The water chemistry is very different in water bodies affected by glaciers. Understand the natural variability so that you can bracket the gradient. Be aware of the effects of invasive species; they can change ecosystems in unexpected ways. Patches interact, through sources and sinks. They found that their presumed "pristine" lakes had been changing and their work demonstrated the dynamics. They observed the strong climate drivers, like the PDO (Pacific Decadal Oscillation). He emphasized the importance of examining the data, every year. After 2 years, you can look at inter-annual differences and over greater time you can look to see if the changes are coherent across the spatial scale of the network. You will get a regional look at variability.

Robert (Bob) Stallard- Bob mentioned that he got his Ph.D. in chemical oceanography and he tends to approach things as in oceanography, where everything is viewed as connected. He likes that approach. He is a landscape biogeochemist that has taken an oceanographic perspective to the terrestrial setting. He has been involved in erosion, sediment transport, geochemistry studies of big rivers (e.g., Amazon, Mississippi, Mackenzie), also large lakes (Superior, Tanganyika), Panama, the Luquilla LTER site in Puerto Rico, S. Cascade Glacier in Washington state.

The chemistry is very different in water bodies affected by glaciers. With climate warming, which he sees as inevitable in the next century, you will see major changes in water chemistry. Because of weathering processes under glaciers, the chemistry is totally different.

He encouraged the group to use the institutional infrastructure you have and build on other's efforts, to complement and add to understanding. He discussed his paper on the possible causes of extinction in Puerto Rican amphibians. Someone told him that all the extinctions were happening above 500 m elevation. It immediately struck him that this is the elevation where the trade winds hit Puerto Rico. He used data sets available on the internet to look for possible sources of pollutants coming to the island. He found that Puerto Rico is not pristine but was getting blasted from many sources, including nitrates, dust from the Sahal, and ozone blasts. His main point in relating this story was that what he called far-field phenomena need to be considered.

He suggested use of a natural laboratory design, using whole systems, to look at both near-field and far-field effects. Pick two systems so you can tell if it is local or global. Build in an internal comparison to help distinguish cause-effect. They used developed and non-developed.

Joe Margraf- Joe stated that he has worked with Jim Larson in the Ugashik Lakes, which has similar problems. He also has a project involving salmon habitat in the Kuskokwim watershed. He is trained as a fisheries ecologist and looks at this from an ecologist perspective, with fisheries in mind. He works largely with exploited species or potentially exploited species.

Joe feels the I&M is a huge undertaking, but we have to do it this way if we are going to get an understanding of how the systems work. It is hard to get your fingers around the whole issue to be able to take a look at it. He emphasized that we think of these as salmon based ecosystems that are largely driven by what happens to the dynamics of salmon.

Besides salmon, global climate change may affect these systems along with other issues such as commercial fish harvest and mining. Increases in tourism mean more demand to access and development of in-holdings.

Day 2 - Workshop Discussion

Objective 1. Review/refine conceptual ecosystem models and monitoring goals and questions- Four conceptual models prepared before the meeting were discussed including models of landscape-level physical forces and energy flow, trophic interactions in river/lake systems, high latitude climate effects on rivers, and a human effects model.

Workshop participants did not discuss each of the models in detail. One participant stated that the models were too specific at the level of lake and river and not detailed enough at the level of the landscape. More emphasis is needed on the physical drivers. Other more specific recommendations included:

1. Modify the landscape physical forces model to depict linkages between flow systems along an elevational gradient.
2. Produce a non-salmon based trophic model in addition to a salmon-based system model.
3. In addition to conceptual models, add physical landscape models such as Digital Elevation Models (DEM); Watershed Characteristics and Statistic Models (RIVER TOOLS); and Altitude Models (from DEM).
4. Use physical models to depict features such as the extent of maximum glacial coverage and locations of any refugia.

Monitoring goals and questions were reviewed after participants discussed the models and again at the end of the workshop. Specific modifications to the goals and other recommendations included:

Goal 1- Change wording to: “Observe and understand dynamics and long-term trends in the physical, chemical, and biotic features of large river and lake systems across the network.” This change reflects the observation that one must first observe, then understand, the dynamics that will account for long-term trends.

Goal 2- Change wording to: “Understand how landscape, oceanic, and atmospheric processes interact with rivers, lakes, and wetlands to affect park resources that are ecological “keystones” or highly valued by stakeholders and visitors.” This change reflects the recommendation that landscape, not ecosystem, is the focus of study in this long-term monitoring effort.

Goal 3- “Understand how near-field and far-field human effects interact with aquatic ecosystems to affect physical and biotic components and processes.” This change reflects the recommendation that it is more meaningful to distinguish between near-field and far-field human effects.

Objective 2. Identify drivers of change and why it is important to understand them-

A round robin brainstorming process was used to generate a long list of potential drivers of freshwater ecosystem change. The drivers were sorted into “driver groups” which were used as starting points for the remainder of the workshop.

Overarching, Driver Themes:

Physical Hydrography

- Water Level
- Water Movement
- Flow - Includes lakes, rivers, and ground water
- Sediment Dynamics
- Glacier/snow/ice
- Erosion

Climate

- Glacier/snow/ice
- Precipitation
- Geologic setting/context
- Tidal Influences
- Permafrost
- Wind
- Insulation
- Temperature
- Fire

Geology and Land Cover

- Sediment Dynamic – related to the physical hydrology
- Glacier/ - (may not include snow/ice)
- Erosion
- Volcanoes
- Fire
- Isostatic Rebound

Major Disturbance Events
- Volcanoes
- Land slides and mass wasting
- Fire
- Earthquakes
- New and old pathogens
- New exotics

Biological Interactions
- Changes in geographic distribution
- Size of salmon runs
- Nutrient Source:
- Salmon Runs
- Range extensions
- Exotics species
- Variation in size
- Species Composition
- Ecological succession
- Extinction (extinctions)
- Consumptive processes (with animals, etc.)
- Pathogens (old & New)

Near-Field Human Effects
- Fisheries
- Land use development
- User Days on Field
- Supplementation
- Water extraction
- Forestry practices
- Nutrient Loading (Eutrophication)

Far-Field Human Effects
- Persistent Pollutants
- Marine fishing

Long Range Transport

Bottle necks – should be placed under several themes

Emerging pathogens

Day 3 – Workshop Discussion Continued

Objective 3. Identify candidate attributes to monitor that provide reliable signals about landscape change- Workshop participants listed prospective attributes or variables for monitoring based on the conceptual models and system drivers identified during day 2. Discussions were organized and lists generated under the categories of climate, physical hydrology, biotic interactions, chemical, landcover/geology, major disturbance events, and near-field and far-field human activities. Clearly, the lists are long and range from general to specific.

CLIMATE

What To Monitor	Comments
Glaciers	• Glacial person thinks mass balance would be important but freshwater does not. • Meltwater hydrograph from glacial melt waters.
Snow Pack and Water Equivalent	• Thickness and extent. • Meltwater is important.
Ice	• Break up and freeze dates are more important and more accessible than ice depth. • If winter limnology is done, then ice depth would be important and could be done with that.
Precipitation	• Rain vs. snow.
Wind	• Wind is essential for lake monitoring
Insulation	• (PAR) Need at the surface. Essential for monitoring lakes. May want to look at insulation over time. • (UVB) – this is expensive but may be having major effects. Denali does it. UVB should be done by someone else, it's too much for NPS
Temperature	
Relative Humidity	• Important. You have to measure it.
Evapotranspiration	• If you want to measure evapotranspiration, you need the suite of

	insulation, relative humidity, etc.

PHYSICAL HYDROLOGY

What To Monitor	Comments
Water Level for Lake and Streams	
Water Movement	• Wind effects in lakes (mixing) • Lateral movement of water • Circulation and movement between phases – ground water and surface (streams) • Lateral movement of the river
Flow – Includes Lakes, Rivers and Groundwater	• Volume of water • Discharge surface and ground water • Some people are measuring stable isotopes, as a lazy way of measuring groundwater flow. • Alagnak River gage identified as high priority by IHC.
Sediment Dynamics	• Sediment delivery and storage • Channel structure (braided, meandering) • Type of sediment is important. Suspended sediment effects lake temperature. • Water clarity relates to both biotic interactions and physical factors.
Glaciers	• Meltwater hydrograph from glaciers
Ice Melt	
Snow Melt	
Erosion	• Concentration of flow (landscape scale). • Erosion of watershed would be impossible. Only get to system output. • Can measure sediment transport at different parts of the stream.
Permafrost	• Discontinuous in LACL, intermittent in KATM, (discontinuous spatially). LACL < 20 percent. Too small to be significant.
Hot and Cold springs	• Just takes a few to have huge affects on the chemistry. • Distribution and flow
Hyporheic zone	• Subsurface movement of water important for salmon.

BIOTIC INTERACTIONS

What To Monitor	Comments
Salmon Run Size	• Compare reasonably matched systems with migratory/non-migratory salmon • Distribution/colonization. At KEFJ, salmon have moved in as glaciers receded. • Salmon productivity. • Pacific side - not as many lakes, so the salmon populations are smaller. McNeil River has chum. • Very important to focus on some keystone and charismatic species Biotic and climate need to keep together because of the noise in the system. Pink salmon, huge dynamics.

Fish Community - Species Composition Relative Abundance	• Role in system • Growth rate/size dist. • Shape/morphology Community level knowledge • Species diversity is expensive, requires extensive sampling to capture • Relative abundance • Fishery impacts Resident fish community • Which are abundant enough to sample effectively • White fish – anadromous and resident • Dolly Varden – anadromous and resident
Nutrient Concentration Cycling	Separate from salmon – • Which ions to look at. • Look at the physical hydrology. Don't look at it from biotic interactions, talk about the chemical instead
Exotic Species	• Mysis shrimp • Eurasian watermilfoil • Reed canary grass • Lodgepole pine (planted to replace spruce killed by bark beetle) • Atlantic salmon • Spiny water flea
Ecological Succession	• Link up with major disturbance events • Unique successions are related to glaciers and volcanic areas. • Wetland, lake • Links to Exotics - macrophytes • Focus on a single type succession for rivers – riparian vegetation – flood plains and point bars. pick on type and do it long term/regular • Spruce beetle kill influence on river morphology • Photography/remote sensing
Extinction	• Genetic monitoring – diversity of gene pools. May still have lake trout, but lose genetic diversity. Others aren't sampling for this. Inventory studies have collected genetic samples. Samples are stored.
Consumptive Processes	• Herbivory by zooplankton. • Carcasses
Old & New Pathogens	• Coordinate with NFW Health Survey (US Fish & Wildlife Service) • ADF&G pathology lab database • Toxic accumulation (sculpin, pike, burbot)
Fish Kills	• Document
Mammal and Avian Salmon Consumers	• Black bears and brown bears • River Otter • Wolverine • Eagles • Photographic survey or walking survey to do a carcass count. Abundance of species feeding on carcasses. Look at as responders, rather than quantification of food web.
Plankton	• Body size of zooplankton change with predation • Parameters listed for lake are specific to look at signature for sockeye • Invasive species • Plankton diversity – have to measure from week to week. • Zooplankton, phytoplankton, and benthos change quickly within a season so sampling may need to be done occurs much more frequently than SWAN may be able to do.

Chemical

What To Monitor	Comments
CORE suite • pH • Conductivity • Temperature • Dissolved oxygen	Required by NPS
SECONDARY (simple) suite • Nitrate (N03) • Nitrite (N02) • Organic Nitrogen • Phosphate (P04) • DOC • Chloride • Silicon • Sulfate (S04) • Chlorophyll • Total Suspended Sediments TSS • Volcanic inputs, nutrients,	• Calcium and silica are good indicators for bedrock, so they, along with chloride, are good indicators for geological processes. • Sulfate and chloride are indicators for volcanism. • Chloride is also important because of the tie with the ocean. Sea salt gets blown a couple hundred kilometers inland, and is one way to distinguish run off from sea transport. • Potassium is all tied up with biotic interactions. It's interesting but the relationships are complex.

Land Cover/Geology

What To Monitor	Comments
Geology and Geologic Context	• Wet and dry side • Water flow originates from glacier, lake or stream
Glaciers and Snow pack	
Land Cover	• Use remote sensing, do it every 10 years • May want to purchase the historical images. • Plant cover as baseline
Tidal Influence	
Photo Points	• Choose sites from historic photos, then identify new sites to fill in gaps
Isostatic Rebound	• Use GPS control points to monitor the uplift. UA Fairbanks Geophysical Institute has a site in KEFJ.
Analysis of River System	• RIVER TOOLS. Program uses DEMs to derive the drainage, pick and choose channel profiles. Length of channel per horizontal distance. Origin of the water, which will affect the chemistry.
Sediment Dynamics	• Possibly mapped w/ geologic cover • Habitat inventory, and riparian succession all deal with sediment. • If there is a gage station, cross section would be done.

Major Disturbance Events

What To Monitor	**Comments –** Others will produce products on these
Volcanoes	
Land Slides and Mass Wasting	• Large events can be tracked on aerial photos • Landslide threshold – precipitation needed to trigger landslides
Fire	• History/info
Earthquakes	
New and Old Pathogens	• Fish health surveys
New Exotics	
Logging	

Flooding	

Near-Field Human Activities

What To Monitor	Comments
User Days	• Between NPS improving ways to count users/visitors and F&G fish data, we could have a better estimation of this. • Look at spatial patterns
Fisheries	• Information collected by F&G but state does not monitor • Fisheries with land use development
Subsistence	
Management Actions	• Forest Practices • Stocking fish • Nutrient input from outhouses • NPS's own threat to itself (outhouses, fuel)
Nutrient Loading	• Compliance monitoring
Major Road Development	• Use GIS • Road will change demographics
Access to the Park	• Planes, etc. • Location of air access
Persistent Pollutants	• Atmospheric transport • Mercury with gold mining • Oil with the coast • Could be mapped
Food Conditioning with Wildlife	• Gulls • Bears • Ties in with the Park's Resource Management
Human Population	• Census data • Tax Data

Far-Field Human Activities

What To Monitor	Comments
Persistent Pollutants	• Compare landlocked with anadromous fish • Marine fishing • Atmospheric Transport • Other Fish • Snow above Exit Glacier (Harding Icefield) Use a meteorological station.
Broader Scale Influences/Projected Activities	• Indicators may be price of oil, politics (elections), sociopolitical/economic environment.

Proposed Framework for SWAN Freshwater Monitoring- Final workshop discussions focused on sketching a hypothetical design framework for network monitoring. This session ranged from the identification of sequential steps in planning to the actual allocation of sample sites. It incorporates many of the concepts and theories discussed thoughout the workshop.

A. <u>Modeling</u>: The initial step would utilize DEMs and other existing data layers (some of which may need verification), to analyze the landscape across the four parks and derive (through synthesis of map data) new information on the aquatic landscape. This information will than be used in study design (step B) and to help in choosing the most representative watersheds for monitoring (step C) over all four parks. Gaging data is essential to this effort not just for the obvious flow in rivers, but also for understanding precipitation runoff, snowpack and snow melt, glacier melt, infiltration, changes in permafrost extent, and water budgets. Water flow information is a hydrological integrator for the entire landscape, which in turn affects the biota.

B. <u>Field Study Design</u>: Using information generated in modeling, design a hierarchical sampling and gaging scheme; then scale it back until it meets financial and logistical realities.

Robert Stallard's suggestion for a nested study design-
Ideally, position back to back gage sites on either side of the divide (wet vs. dry) in each park; site meteorological stations at the summits of each divide and at (or closely located with) each gage site.

Park	Wet Side	Drier Side
Lake Clark NPP	watershed 1	watershed 5
Katmai NPP	watershed 2	watershed 6
Kenai Fjords NP	watershed 3	watershed 7
Aniakchak NM	watershed 4	watershed 8

John Magnuson's suggestions on study design-
Choose 6-8 flow systems; distribute them across wet-dry landscapes, considering the origin of the watershed, the geologic basis, etc. (stratification). Within those flow systems (i.e. "watershed" in Stallard's terminology), select approximately five locations along an elevation gradient.

For example, distribute the following sites across the SWAN parks with reference flow (gage) and climate stations for each:

	Gradient 1	Gradient 2	Gradient 3	Gradient 4	Gradient 5
Flow System 1	site 1	site 2	site 3	site 4	site 5
Flow System 2	6	7	8	9	10
Flow System 3	11	12	13	14	15
Flow System 4	16	17	18	19	etc…..
Flow System 5					
Flow System 6					
Flow System 7					
Flow System 8					site 40

In effect, Stallard's and Magnuson's suggestions are very similar. Stallard suggests an overall 4x2 study (four parks by 2 major stratifications, wet and dry) or eight watersheds overall. Magnuson also presents the idea of 6 to 8 watersheds, but he takes it a step further to suggest 5 gradient sites within each selected flow system ("watershed"). Magnuson didn't define the 8 flow systems as being 2 in each park, but instead 8 flow systems distributed across wet/dry, geologic, salmon abundance or lack of, glacial vs. nonglacial, etc. This information would be illustrated in the Step A modeling.

C. Within Watershed Site Selection

As mentioned above, sites selected within watersheds (i.e. flow systems) would be based on the information derived from the modeling in Step A. Magnuson and Stallard seemed to approach this stratification idea similarly (although the technology of the modeling was more from Stallard's research camp.)

The sites selected within a watershed might be of two or more levels – for example, Magnuson suggested thinking about primary vs. secondary sites - primary being the regularly scheduled sites, and secondary being the "opportunistic" sites. This thinking would help as logistics and finances are reviewed and sites must be trimmed.

D. Variables

1) Core variables: Water temperature; conductivity; pH; dissolved oxygen; flow (quantitative or qualitative) Stallard's message: "some gages are essential" to run this monitoring program

2) Basic Suite: Nitrate, nitrite, phosphate, organic nitrogen, dissolved organic carbon (DOC), chloride, silica, sulfate, chlorophyll, total suspended solids (TSS); volcanic markers.

3) LTER Suite: This includes the basic variables plus suite of major cations and anions.

4) NAWQA Suite: Complete set (includes the basic variables, ions, trace elements, metals, select contaminants, sediment chemistry, inverts, etc.); with a quantified flow, preferably at a gage site. Analysis runs USGS about $12,000.00 for this suite.

5) Sediment/ice Core samples- -periodically (These can be stored for later analyses when funding is available.) This is a good technique to track long distance/aerial input for contaminants such as mercury.

Along with considering the number of monitoring sites and the sampling recurrence at each site, the variable suites above can be selected at different levels (1-4) to back into the costs and logistics of the SWAN program.

When considering variables to measure, sort the different approaches to get an efficiency of funding and geographical coverage. For example, use some state of the art methods (Doppler detection for glacier movement, super-clean contaminant chemistry, ice core analysis, etc), some standard methods (in-field chemistry, basic chem/physical variables), and some simple, observer-based methods (such as ice-on, ice depth recorded by local observers). A mix of methods is appropriate.

Magnuson urged caution on zooplankton, phytoplankton, and benthos. They change quickly within a season so it's hard to track the fast dynamics and processes unless sampling occurs much more frequently than SWAN may be able to do.

Consider opportunistic, catastrophic events – such as fish kills, volcanic eruption, earthquake, etc., when designing the monitoring plan. Think through the variables and the approach to what should be monitored in these events.

Appendix A: Invited Participants

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